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(54) **VEHICLE DOOR HANDLE HAVING ICE HANDLING**

(56) **References Cited**

(71) Applicant: **Ford Global Technologies, LLC**,
Dearborn, MI (US)
(72) Inventors: **Stuart C. Salter**, White Lake, MI (US);
David Brian Glickman, Southfield, MI (US);
Paul Kenneth Dellock, Northville, MI (US);
Kosta Papanikolaou, Huntington Woods, MI (US);
Pietro Buttolo, Dearborn Heights, MI (US)

U.S. PATENT DOCUMENTS

7,911,321 B2 3/2011 Bingle et al.
8,091,280 B2 1/2012 Hanzel et al.
8,471,822 B2 6/2013 Lightenberg
8,701,353 B2 4/2014 Patel et al.
8,922,340 B2 12/2014 Salter et al.
9,137,856 B2 9/2015 Thompson et al.
9,151,089 B2* 10/2015 Aerts E05B 85/103
(Continued)

(73) Assignee: **Ford Global Technologies, LLC**,
Dearborn, MI (US)

FOREIGN PATENT DOCUMENTS
CN 202261842 U 5/2012
CN 205086649 U 3/2016
(Continued)

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OTHER PUBLICATIONS

“Touch Sensors Design Guide,” by Atmel, 10620 D-AT42-04/09, Revised Apr. 2009, 72 pages, copyrighted 2008-2009 Atmel Corporation.
(Continued)

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Primary Examiner — Hirdepal Singh
(74) *Attorney, Agent, or Firm* — Vichit Chea; Price Heneveld LLP

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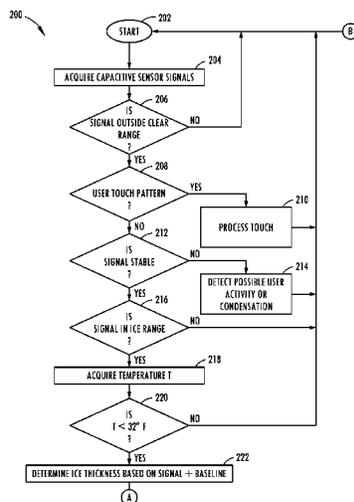
(57) **ABSTRACT**

A vehicle door handle is provided that includes a deployable handle body located on a door, keypad contacts on an outer side of the handle body, an actuator configured to deploy the handle to a deployed position, a plurality of proximity sensors located on the handle body and generating activation fields, and a controller processing signals generated by the sensors to determine an input command for controlling the actuator and to determine a keypad input. The controller may sense ice on the handle and determine ice thickness and may control the actuator to break the ice based on the ice thickness.

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17 Claims, 11 Drawing Sheets



(56)

References Cited

U.S. PATENT DOCUMENTS

9,346,470	B2	5/2016	Mittermeier	
9,423,895	B2	8/2016	Adamson et al.	
9,447,613	B2	9/2016	Salter et al.	
9,512,662	B1	12/2016	Dudar et al.	
9,637,088	B2	5/2017	Ette et al.	
9,646,436	B1	5/2017	Campbell et al.	
9,696,839	B1	7/2017	Bingle et al.	
9,745,778	B1*	8/2017	Bingle	E05B 81/78
10,124,767	B1	11/2018	Salter et al.	
2011/0148575	A1	6/2011	Sobecki et al.	
2012/0119524	A1*	5/2012	Bingle	E05B 81/28 292/336.3
2014/0000165	A1	1/2014	Patel et al.	
2014/0000167	A1*	1/2014	Patel	E05B 81/34 49/32
2014/0069015	A1	3/2014	Salter et al.	
2015/0315839	A1	11/2015	Shigemoto et al.	
2015/0330112	A1	11/2015	Van Wiemeersch et al.	
2015/0330117	A1*	11/2015	Van Wiemeersch	E05B 85/14 292/96
2016/0251880	A1	9/2016	Bingle et al.	
2016/0333627	A1*	11/2016	Dudar	E05F 15/71
2017/0103592	A1	4/2017	Buttolo et al.	
2017/0232932	A1	8/2017	Nishidai et al.	
2017/0260778	A1*	9/2017	Witte	E05B 81/77
2018/0012431	A1*	1/2018	Murphy	E05F 15/46

FOREIGN PATENT DOCUMENTS

CN	107575101	A	1/2018
DE	102006019581	B4	11/2014
DE	102013013203	A1	2/2015
JP	2008063907	A	3/2008
JP	4146601	B2	6/2008
JP	4161898	B2	8/2008
JP	2009079353	A	4/2009
JP	5309515	B2	7/2013
KR	1020130094569	A	8/2013

OTHER PUBLICATIONS

U.S. Appl. No. 15/882,191, filed Jan. 29, 2018, entitled "Vehicle Exterior Keypad Having Interior Lamp," 4 pages of filing receipt, 13 pages of patent application and 6 pages of drawings.
 Tesla Model S—Cold Weather Performance, Published Nov. 22, 2013 on YouTube, <https://www.youtube.com/watch?v=GS9uDJGi52A&feature=c4-overview&list=UU5WjFriBdufl6CZojX3D8dQ>, 3 pages.
 How to—Range Rover Velar (2017) Vehicle Feature: Gesture Tailgate, Published Jul. 14, 2017 on YouTube, <https://www.youtube.com/watch?v=RjhYd2b1ZIE>, 1 page.

* cited by examiner

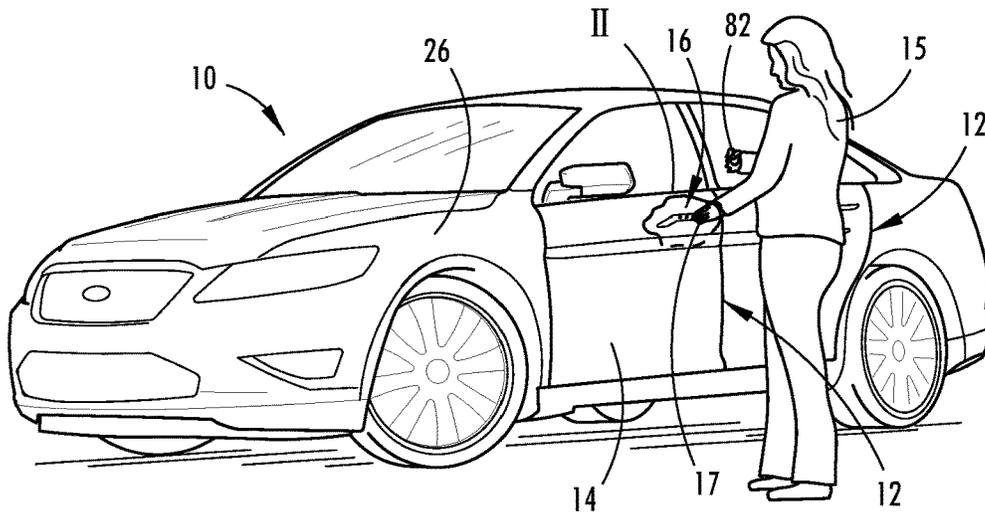


FIG. 1

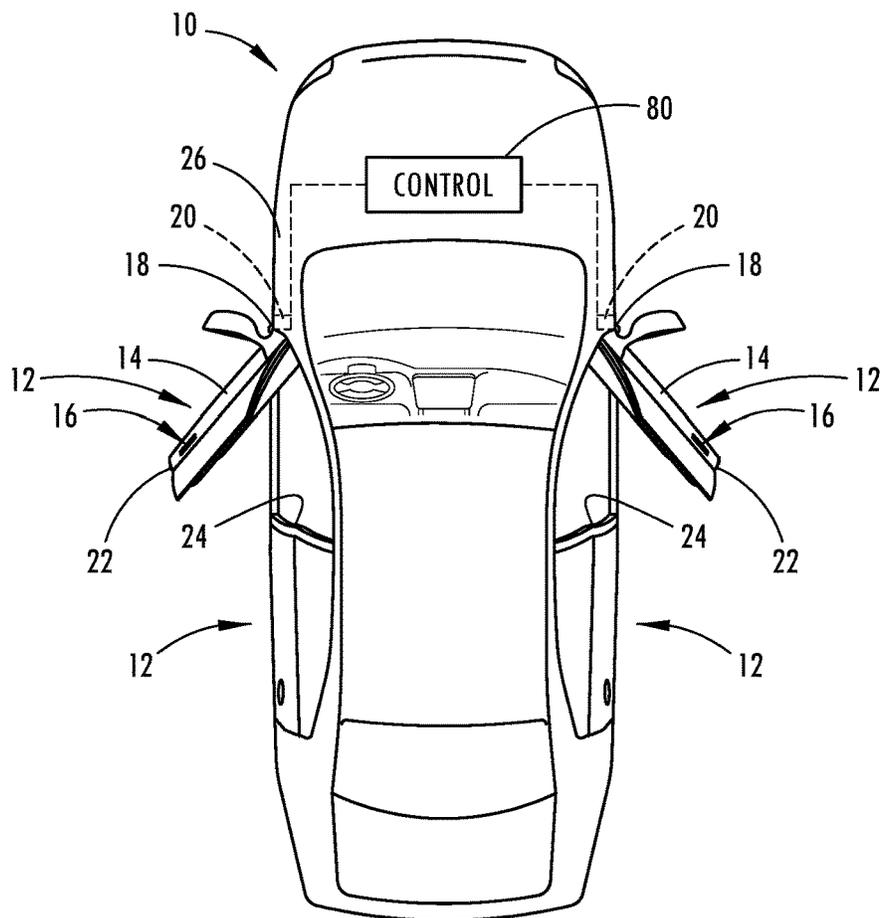


FIG. 2

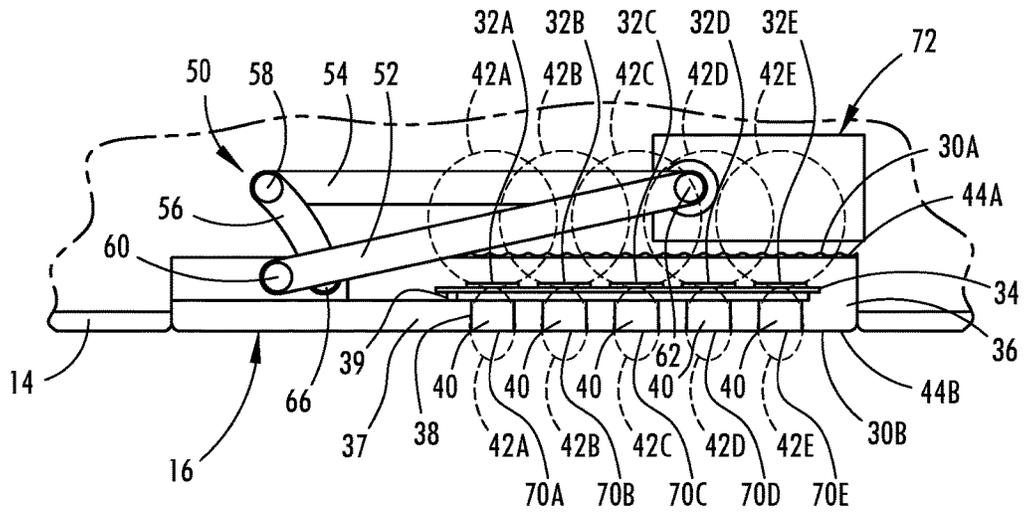


FIG. 4A

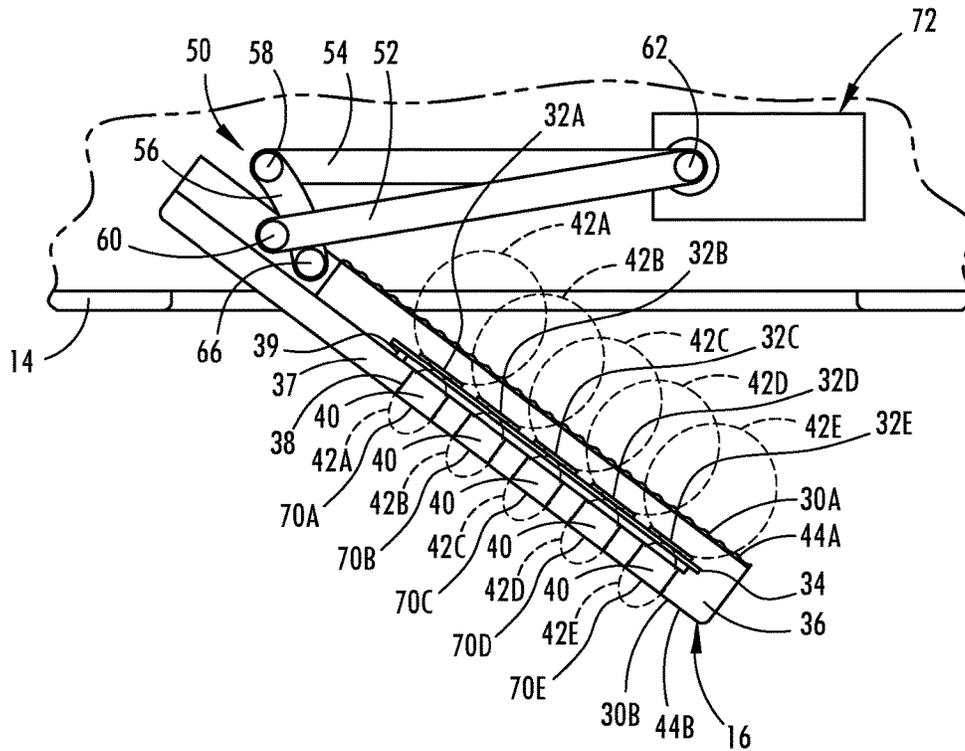


FIG. 4B

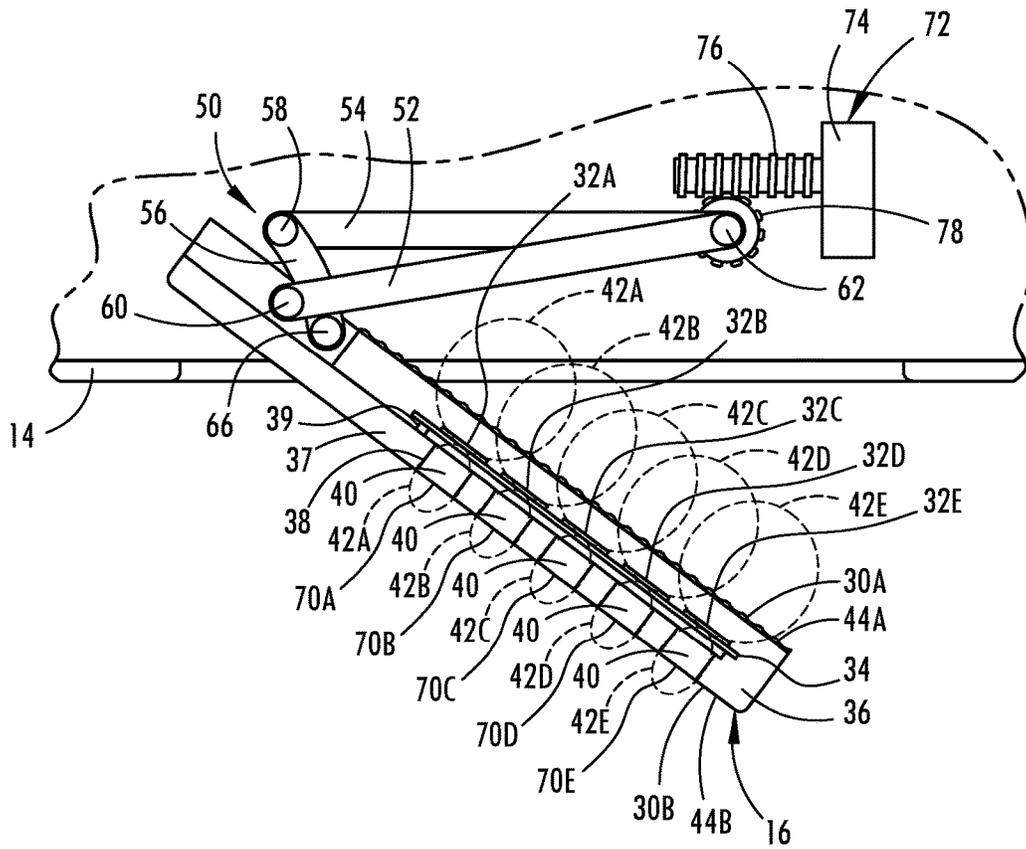


FIG. 4C

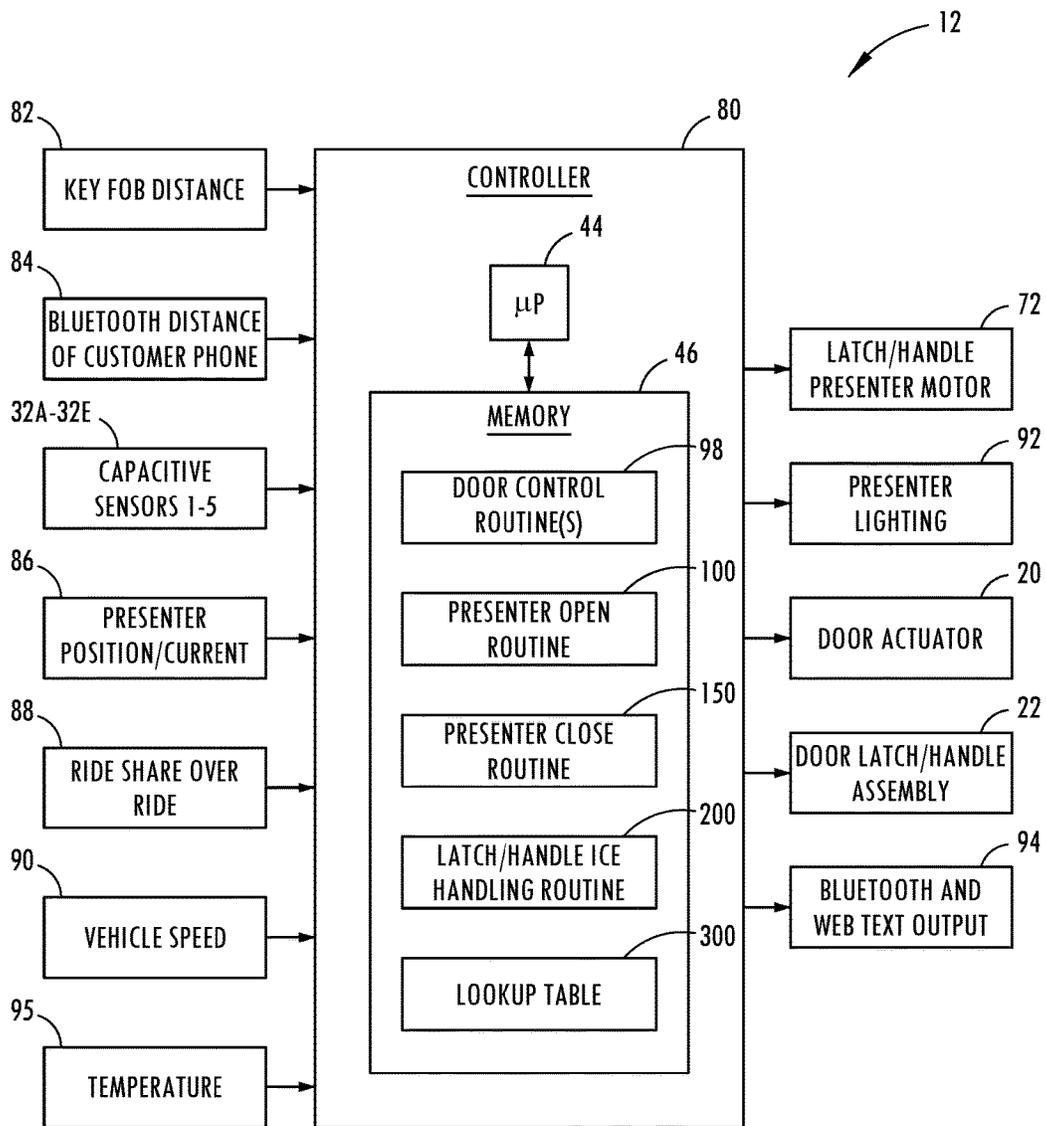


FIG. 5

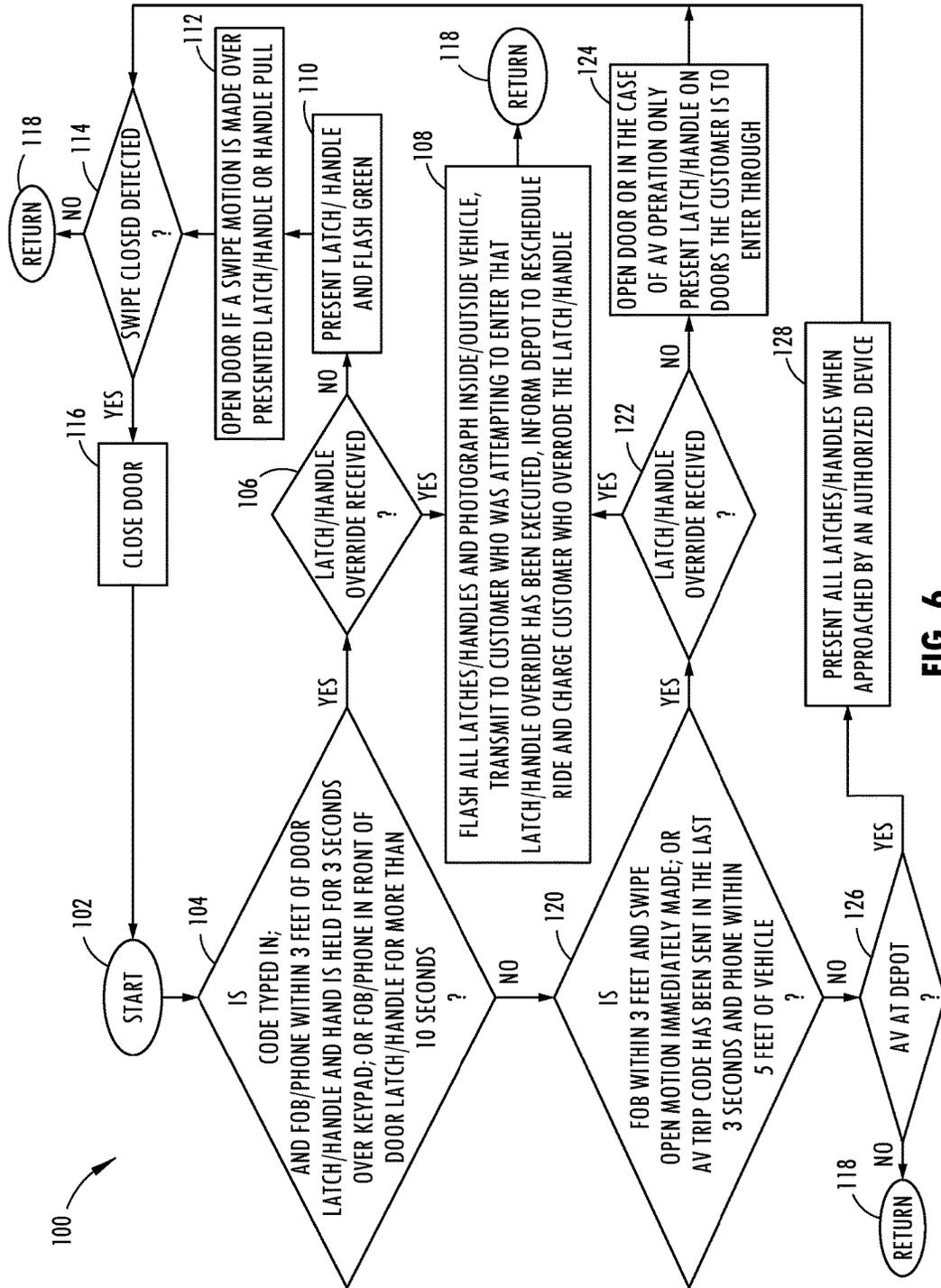


FIG. 6

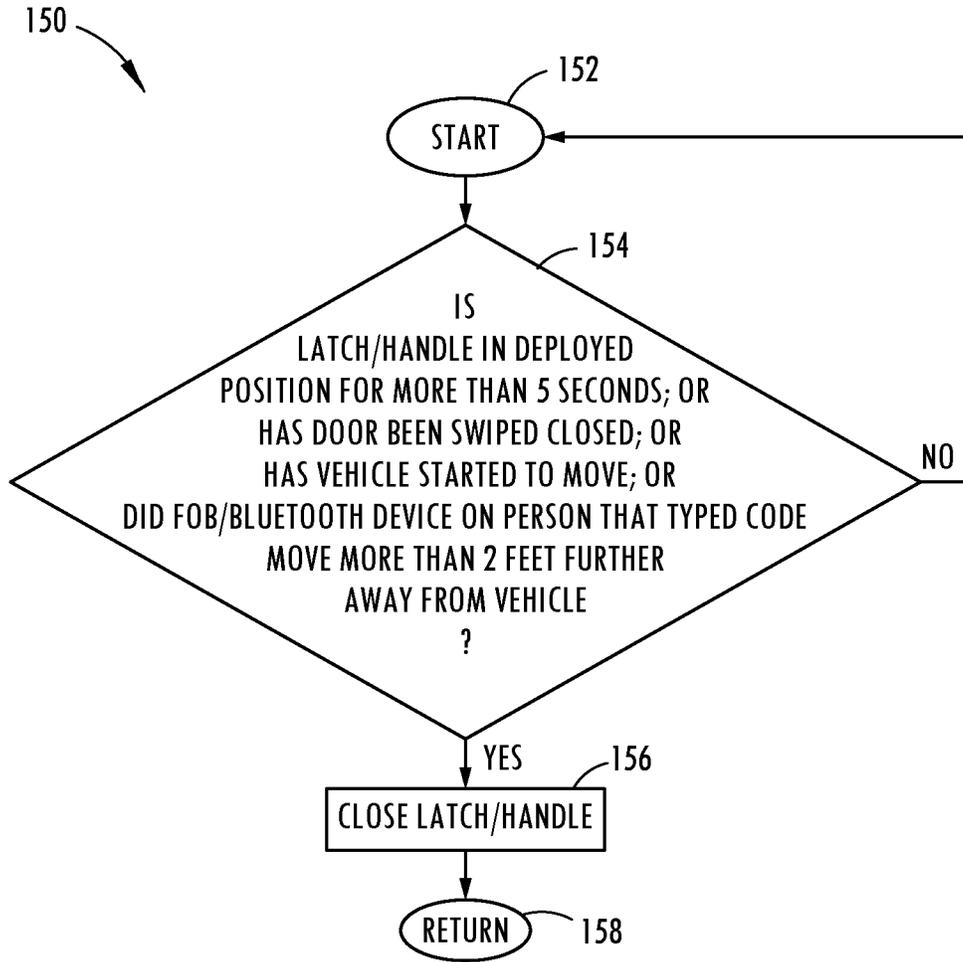


FIG. 7

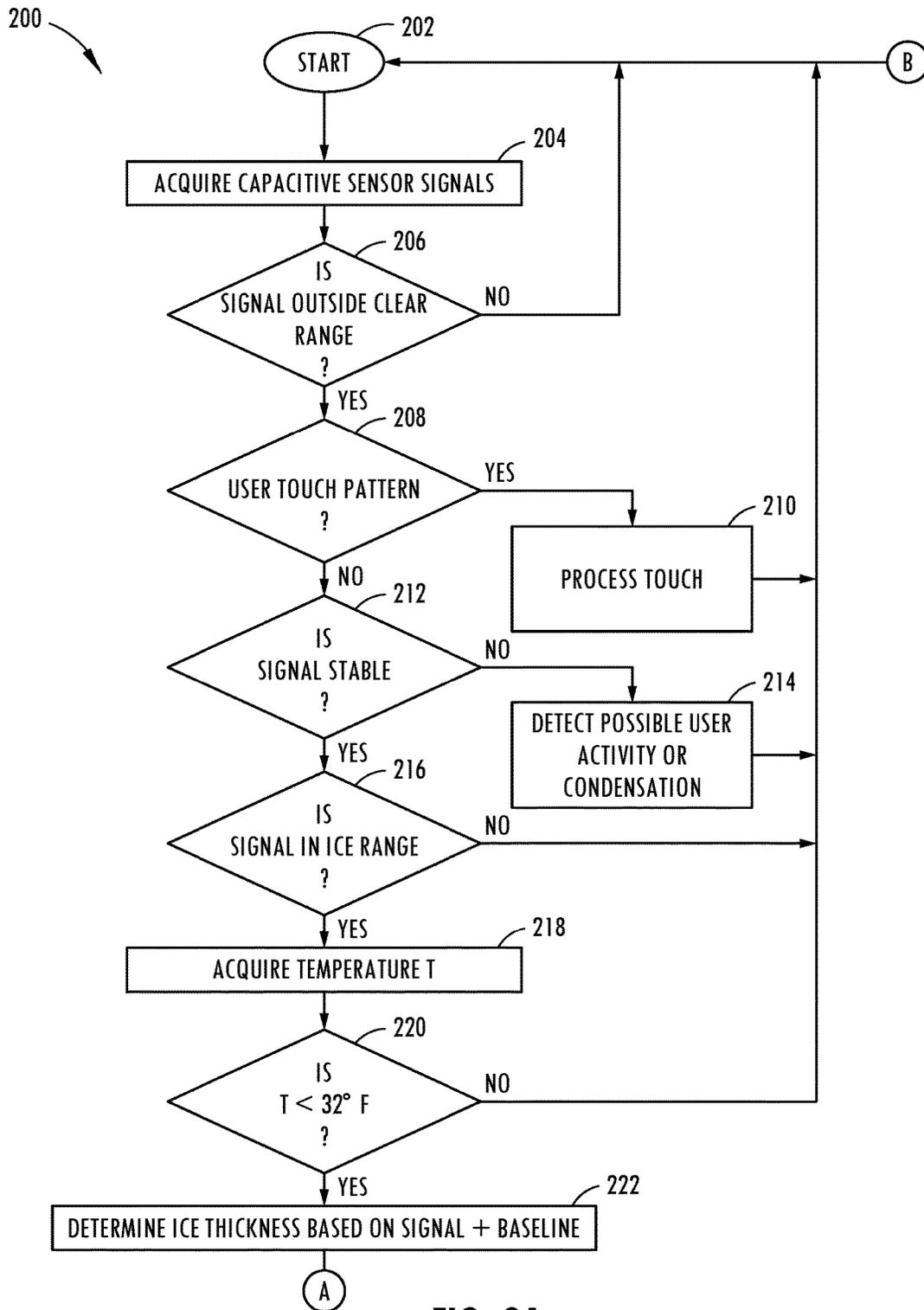


FIG. 8A

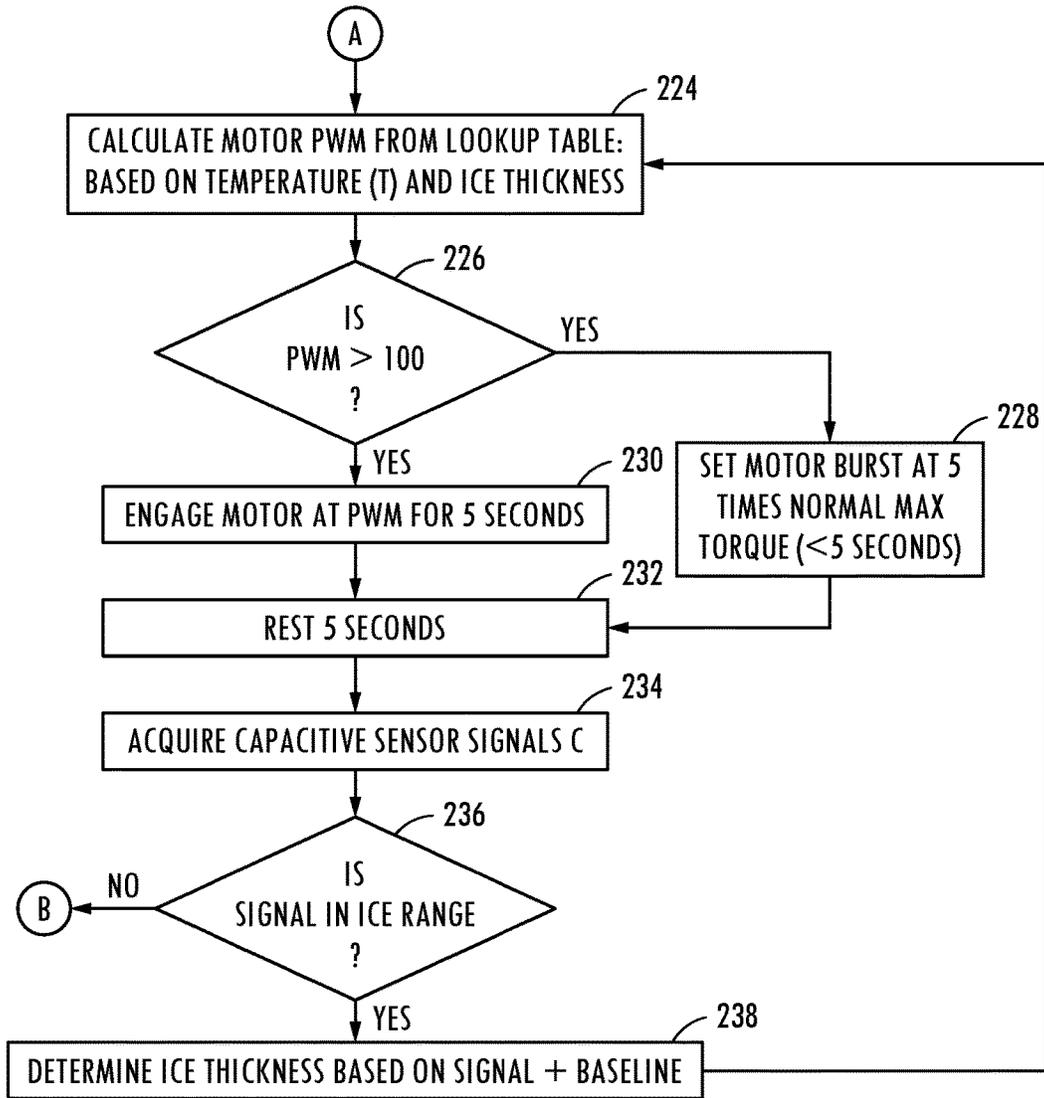


FIG. 8B

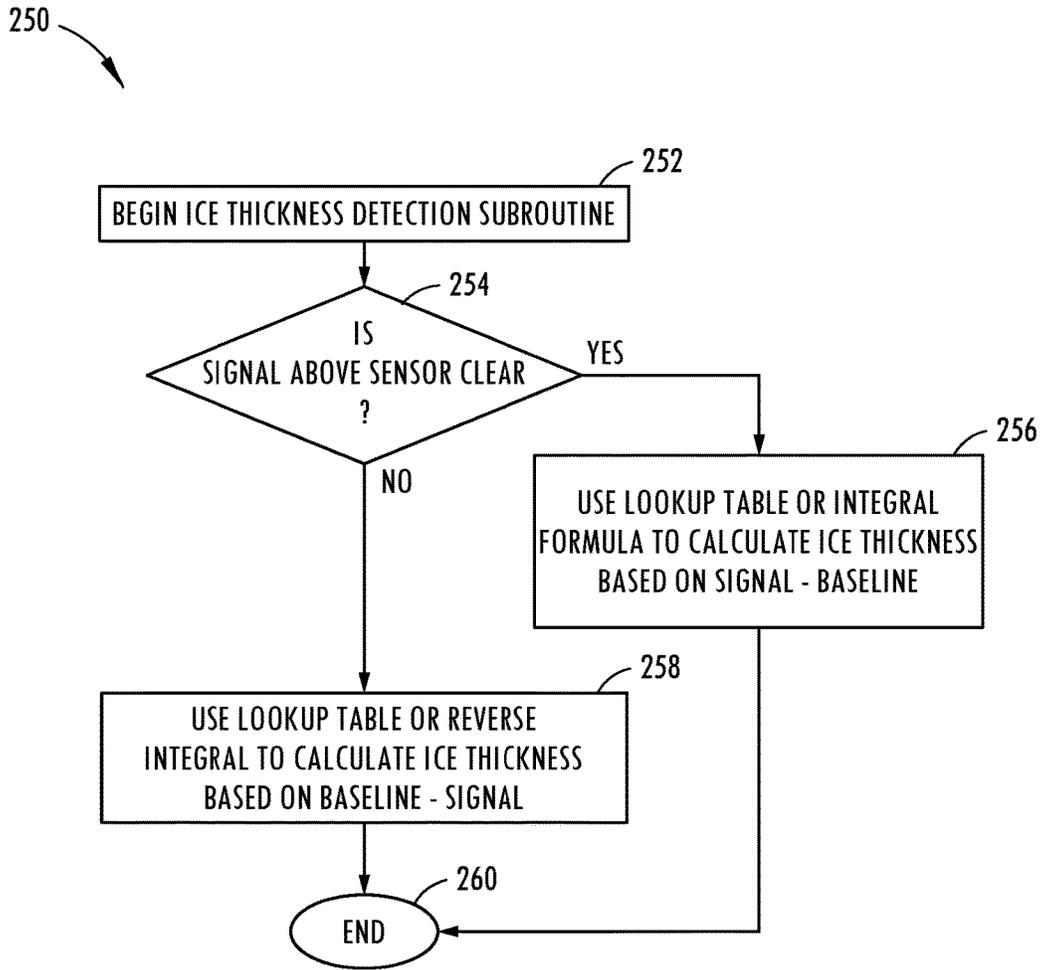


FIG. 9

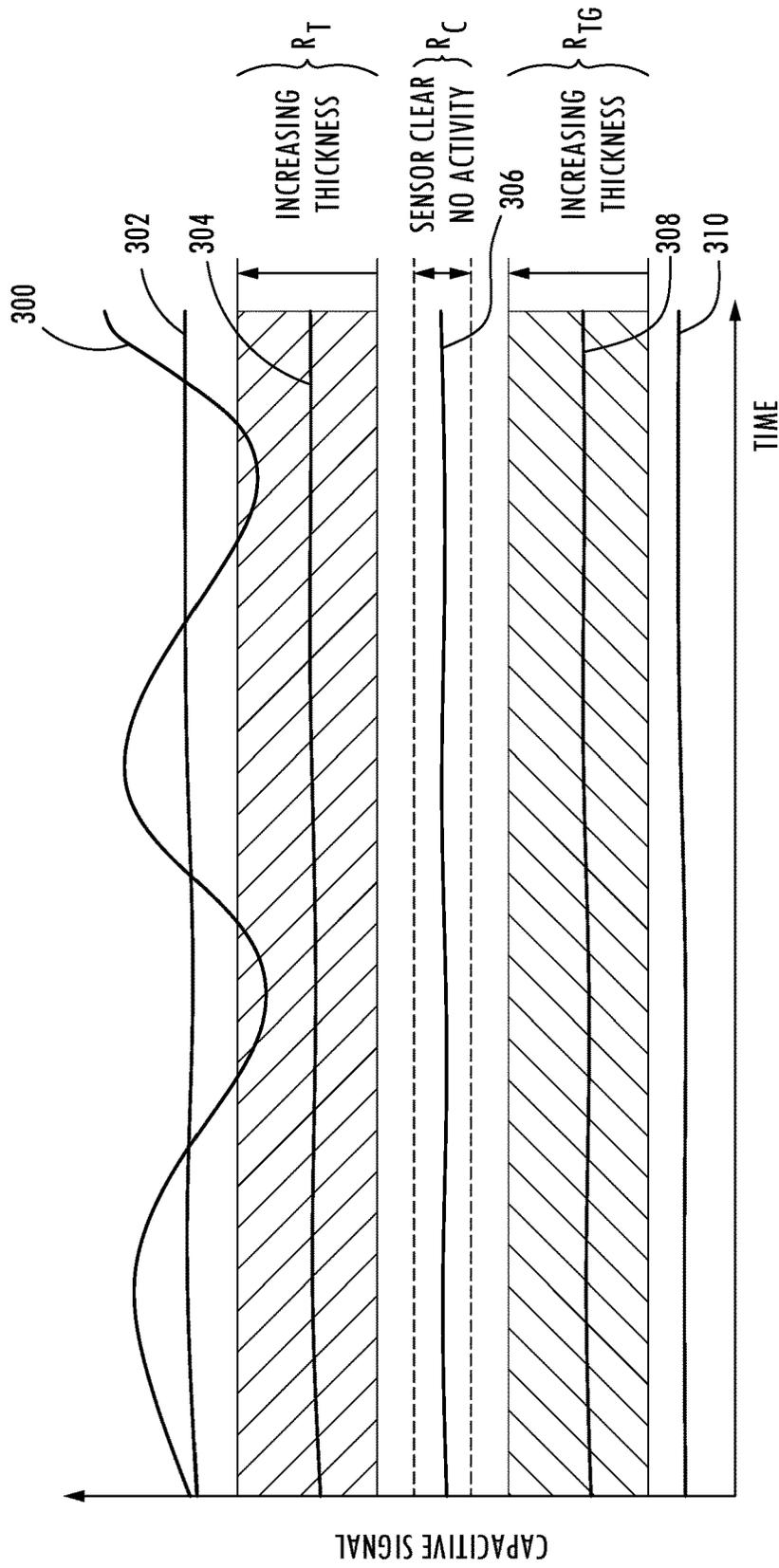


FIG. 10

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VEHICLE DOOR HANDLE HAVING ICE HANDLING

FIELD OF THE INVENTION

The present invention generally relates to powered vehicle doors, and more particularly relates to a powered vehicle door having door control inputs sensed via proximity sensing.

BACKGROUND OF THE INVENTION

Automotive vehicles include various door assemblies for allowing access to the vehicle, such as passenger doors allowing access to the passenger compartment. The vehicle doors typically include a door handle and a latch assembly that latches the door in the closed position and is operable by a user to unlatch the door to allow the door to open. The doors may pivot or slide on a track between open and closed positions. Some vehicle doors are equipped with a motor to provide power door opening assist to open the door. Upon receiving a user input, the motor actuates the door to an open position or a closed position. Some vehicle doors further employ deployable handles. It is desirable to provide for vehicle door controls that provides enhanced functionality.

SUMMARY OF THE INVENTION

According to a first aspect of the present invention, a vehicle door handle is provided with a handle body. The vehicle door handle has at least one capacitive sensor for sensing ice is disposed on the handle body and an actuator actuates the handle body. A controller controls activation of the actuator based on the sensed ice.

Embodiments of the first aspect of the invention can include any one or a combination of the following features:

- the at least one capacitive sensor senses a thickness of the ice and the controller controls actuation of the actuator based on the sensed thickness;
- a temperature sensor for sensing temperature proximate the handle body, wherein the controller controls the activation of the actuator further based on the sensed temperature;
- the actuator comprises a motor;
- the controller activates the motor with increased torque when an increased thickness of ice is sensed;
- the controller controls a pulse width modulation signal of the motor to control the torque;
- the at least one capacitive sensor comprises a plurality of capacitive sensors;
- a plurality of keypad contacts, wherein the plurality of capacitive sensors are arranged to sense inputs applied to respective keypad contacts;
- the plurality of capacitive sensors sense a gesture command;
- the handle body is deployable between a stowed position and an extended deployed position; and
- the handle body pivots between the stowed and extended deployed positions.

According to a second aspect of the present invention, a vehicle door handle is provided. The vehicle door handle includes a handle body located on a door, a plurality of keypad contacts, and a plurality of capacitive sensors that sense ice on the handle body. An actuator actuates the handle body to a deployed position. A controller controls activation of the actuator based on the sensed ice.

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Embodiments of the second aspect of the invention can include any one or a combination of the following features:

- the at least one capacitive sensor senses a thickness of the ice and the controller controls actuation of the actuator based on the sensed thickness;
- a temperature sensor for sensing temperature proximate the handle body, wherein the controller activates the actuator further based on the sensed temperature;
- the actuator comprises a motor;
- the controller activates the motor based on increased torque when an increased thickness of ice is sensed;
- the controller controls a pulse width modulation signal of the motor to control the torque;
- the plurality of capacitive sensors are arranged to sense inputs applied to respective keypad contacts;
- the plurality of capacitive sensors sense a gesture command; and
- the handle body is deployable between a stowed position and an extended deployed position.

These and other aspects, objects, and features of the present invention will be understood and appreciated by those skilled in the art upon studying the following specification, claims, and appended drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

In the drawings:

FIG. 1 is a side perspective view of a motor vehicle having doors equipped with deployable door handles having proximity sensed input controls, according to one embodiment;

FIG. 2 is a top view of the vehicle further illustrating the two forwardmost powered doors in the open position;

FIG. 3 is an enlarged view of section II of FIG. 1 further illustrating the deployable vehicle door handle in the flush retracted stowed position and a hand gesture input command;

FIG. 4A is a schematic top cut away view of the deployable door handle shown in the flush retracted stowed position and employing a direct drive motor assembly, according to one embodiment;

FIG. 4B is a schematic top cut away view of the deployable door handle of FIG. 4A shown in the extended position;

FIG. 4C is a schematic top cut away view of the deployable door handle in the extended position and employing a worm gear and motor assembly, according to another embodiment;

FIG. 5 is a block diagram illustrated controls for processing the proximity sensors associated with the door handle and controlling the door and handle actuators;

FIG. 6 is a flow diagram illustrating a door handle presenter open routine;

FIG. 7 is a flow diagram illustrating a door handle presenter close routine;

FIG. 8A is a flow diagram illustrating a door handle ice handling routine for sensing and breaking ice;

FIG. 8B is a flow diagram further illustrating the door handle ice handling routine of FIG. 8A;

FIG. 9 is a flow diagram illustrating a subroutine for sensing ice thickness on the door handle, according to one embodiment; and

FIG. 10 is a signal diagram illustrating examples of capacitive sensor signals processed to determine presence of ice and ice thickness.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

For purposes of description herein, the terms "upper," "lower," "right," "left," "rear," "front," "vertical," "horizon-

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tal,” “interior,” “exterior” and derivatives thereof shall relate to the invention as oriented in FIG. 1. However, it is to be understood that the invention may assume various alternative orientations, except where expressly specified to the contrary. It is also to be understood that the specific devices and processes illustrated in the attached drawings, and described in the following specification are simply exemplary embodiments of the inventive concepts defined in the appended claims. Hence, specific dimensions and other physical characteristics relating to the embodiments disclosed herein are not to be considered as limiting, unless the claims expressly state otherwise.

Referring now to FIGS. 1 and 2, a wheeled motor vehicle 10 is generally illustrated having a plurality of variable-speed powered doors equipped with deployable door handles having proximity sensor based controls, according to one embodiment. The vehicle 10 includes vehicle doors 16 provided on opposite sides of the vehicle 10. In the embodiment shown, the vehicle 10 has a front door and a rear door on a first or driver’s side of the vehicle 10 to enable the driver and passengers to enter and exit the seating compartment from the first side, and a front door and a rear door on the opposite second or passenger’s side of the vehicle 10 to enable passengers to access the seating compartment from the second side. The vehicle doors 12 each include a door panel 14 pivotally connected to a frame or body 26 of the vehicle 10. The connection between each door panel 14 and body 26 may include one or more hinge assemblies 18 that allow the door 12 to swing about the hinge assembly 18 between the closed and open positions. While the doors 12 are pivoting doors in the embodiment shown, it should be appreciated that one or more of the doors 12 could otherwise move between open and closed positions, such as sliding doors.

Each door 12 also includes a deployable door handle 16 located on the exterior side of the door panel 14. The door handle 16 has a deployable handle body shown and described herein as a flush mounted handle body in the stowed position that pivots and extends outward to a deployed position so that a user may grip or interface with the handle 16. The door handle 16 has a first contact surface on a first or inner side to enable a user to contact the door handle 16 when in the deployed position to input door control commands that may include a door open command, a door closing command and door opening speed commands. The door handle 16 has a second contact surface, shown with five keypad contacts on a second or outer side to enable a user to input door handle commands such as keypad inputs to deploy the handle body and input gesture commands such as a swipe command to open or close the door. It should be appreciated that the door handle 16 may have other shapes, sizes and configurations.

The door handle 16 has a handle actuator configured to deploy the handle body outward to the outward extending deployed position and back inward to the stowed position. The handle actuator may include an electric motor located within the door 12 that may directly drive or may drive via a worm gear and wheel the handle body between the extended and stowed positions. The door handle actuator may actuate the handle 16 based on user inputs such as a keypad input.

The door 12 includes a door actuator such as an electric motor 20 shown located near the hinge assembly 18. The motor 20 is actuatable in a first direction to open the door to an open position. The motor 20 may also be actuatable in the reverse second direction to close the door to a closed position. The door actuator may operate at multiple speeds

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in response to a sensed user hand contacting the first contact surface on the inner side of the handle to input a door speed control command or a user inputting a swipe gesture command proximate the second contact surface on the outer side of the handle. For example, the door panel 14 may be opened at a first slow speed, or a second middle or normal speed which is faster than the first speed, or a fast third speed which is faster than the second speed, depending on the amount of contact area sensed on the first contact surface of the door handle or speed of a swipe gesture proximate the second contact surface as sensed by a proximity sensor arrangement. The activation may also close the door at one or more speeds.

The vehicle door 12 may further include a door latch assembly 22 configured to engage a latch mechanism 24 on the vehicle body 26 when the door panel 14 is in the closed position. The door latch assembly 22 may be electronically controlled to latch and unlatch the door 12 based on a user input as sensed by the proximity sensor arrangement. For example, the latch assembly 22 may unlatch when either a user’s hand is detected or sensed contacting the first contact surface on the inner side of the deployed door handle 16 or a swipe gesture command is detected on the second contact surface on the outer surface of the stowed door handle 16, and a vehicle key fob 82 (FIG. 3) or other electronic device such as a smartphone is sensed in close proximity (e.g., within one meter) to the corresponding vehicle door 12. When the door is closed, the latch assembly 22 will latch onto the latch mechanism 24 on the vehicle body 26 to keep the door 12 latched in the closed position. It should be appreciated that various latch configurations may be used. It should also be appreciated that the door latch assembly 22 may otherwise be controlled with a key fob or with user input controls provided on the vehicle 10.

Referring to FIGS. 3-4B, the door 12 and the door handle 16 are further illustrated in greater detail in both a flush stowed position and an outward extended deployed position. The door handle 16 is shown located on the exterior surface of the door panel 14 and is flush mounted within the door panel 14 when in the flush stowed position as shown in FIGS. 3 and 4A. A user may input a gesture swipe command via the user’s hand 17 by swiping across capacitive sensors arranged in the handle body from left to right to open the door or from right to left to close the door, for example. This gesture swipe command may occur with the handle body in the stowed position or in the extended position. A handle motor 72 may be activated to pivot the handle 16 from the flush stowed position shown in FIG. 4A to the outward extended deployed position shown in FIG. 4B in which the vehicle rearward portion of the handle 16 extends outward from the vehicle door. The handle 16 has a handle body 36 configured with a first or inner side 44A and a second or outer side 44B which is exposed to a user positioned outside of the vehicle 10. The outer side 44B of the handle 16 includes a plurality of keypad inputs 70A-70E, which enable a user to sequentially enter keypad inputs to deploy the handle 16 and to unlock and lock the door. Thus, when the handle 16 is in the flush stowed position, the user may enter a sequence of codes on the keypad to deploy the handle 16 and to unlock or lock the door latch assembly 22 on the door 12. The keypad inputs 70A-70E may be positioned on a flush surface or may have contoured touch pads.

Referring to FIGS. 4A and 4B, the door handle 16 is generally shown as a deployable handle that may deploy from the flush stowed position shown in FIG. 4A to an extended deployed position shown in FIG. 4B in which the handle 16 is pivoted outward to enable a user to grip the

handle 16 on the inner side 44A to enable the user to apply a handle pull force and input a door command signal to unlatch the door 12, actuate the door to the open position at a select speed, and to actuate the door to the closed position. The deployable door handle 16 pivots about a hinge assembly 50. The hinge assembly 50 may be configured to provide an over center pivoting rotation of the door handle 16. When the handle motor 72 is activated for extending the handle, the hinge assembly 50 pivots the vehicle rearward portion of the handle 16 outward to the deployed position extending outward at an angle in the range of fifteen degrees to sixty degrees (15°-60°).

The hinge assembly 50 includes a first rod 52 pivotally connected on one end to one end of a second rod 54 via a first pivot pin 62. The opposite end of the first rod 52 is connected to a second pivot pin 60. The opposite end of the second rod 54 is connected to a third rod 56 via a third pivot pin 58. The opposite end of the third rod 56 is connected to a fourth pivot pin 66. The handle motor 70 is illustrated as a direct drive motor in FIGS. 4A and 4B for actuating the door handle between stowed and extended deployed positions, according to one embodiment. In this embodiment, the handle motor 72 is connected to the first pivot pin 62 which connects to rods 52 and 54. The motor 72 may push on rod 52 to cause the handle body 36 to pivot towards the stowed position and may pull on rod 62 to cause the handle body 36 to move towards the extended position.

According to another embodiment shown in FIG. 4C, the handle motor 72 may be configured with a worm gear 76 that engages a wheel 78 that, in turn, is connected to the first pivot pin 62. As such, the motor 72 rotates the worm gear 76 to turn wheel 78 to move rod 52 forward and backward to cause the handle body 36 to move between the stowed and extended positions. It should further be appreciated that the handle 16 may otherwise be configured with an actuator to move between the stowed and extended positions. Further, the handle may be manually activated to the extended position by a user applying inward force on the leftmost end of the handle body.

The door handle 16 includes a proximity sensor arrangement 32 located on the door handle body 36 and configured to sense a user's hand interfacing with the door handle 16 both on the first contact surface 30A on the inner side 44A of the door handle 16 and on the second contact surface 30B on the outer side of the door handle 16. The proximity sensor arrangement 32 has one or more proximity sensors configured to sense a user in close proximity, e.g., within one millimeter, or in contact with the first contact surface 30A on the inner side 44A of the door handle 16 and on the second contact surface 30B on the outer side 44B of the door handle 16. In the embodiment shown, the proximity sensor arrangement 32 includes five proximity sensors 32A-32E shown evenly spaced along a length of the handle body 36 of the door handle 16 for generating corresponding sense activation fields 42A-42E. The sense activation fields 42A-42E operate as sensing fields and are shown extending on the inner side 44A of the handle 16 and overlapping with one another and sufficiently covering the first contact surface 30A and further extending on the outer side 44B of the handle 16 in narrow fields that do not overlap with each other and cover the second contact surface 30B which has keypad contact surfaces for five individual keypads. Each of the proximity sensors 32A-32E generates a sense activation field 42A-42E and generates a signal in response to sensed interference with the corresponding sense activation field. The signal generated with each proximity sensor 32A-32E is processed by a controller to detect the presence of a user e.g.,

hand or one or more fingers of a user, within the sense activation field and generates a signal amplitude dependent upon the amount of interference or contact with the contact surface 30 on the inner side 44A or the outer side 44B within the sense activation field. For example, when a user's hand or finger lightly touches the inner side 44A of the door handle 16, a relatively smaller amplitude signal is generated, whereas if the user's hand pulls on the inner side 44A of the door handle 16 on the contact surface 30, the amount of signal amplitude generated by each sensor is greater.

The proximity sensors 32A-32E are located within a housing of the handle body 36 of door handle 16 in close proximity to the first contact surface 30A. The door handle 16, particularly the first contact surface 30 on the inner side 44A, is preferably made of a material, such as polymeric material, that does not interfere with the sense activation fields 42A-42E. The inner side 44B of the handle may have a roughened surface or gripping pattern for enhanced gripping. Each of the proximity sensors 32A-32E is located on a printed circuit board 34 which may include other electrical circuitry. The printed circuit board 34 includes a controller or control circuitry which may include a microprocessor which may be electrically connected to the proximity sensors 32A-32E and may process the signal generated by each of the sensors 30A-32E. It should be appreciated that each of the proximity sensors 32A-32E are located on one side of the printed circuit board 34 facing towards the first contact surface 30A on the inner side 44A of the door handle 16. A ground layer 37 is disposed on the opposite side of the printed circuit board 34 and thus is located on the side of the circuit board 34 generally facing towards the outer side 44B of the door handle 16. The ground layer 37 is made of an electrically conductive material that is grounded to an electrical ground. The ground layer 37 provides a beam shaping shield located between the sensors 32A-32E and the outer side 44B to generate a narrower sensing field on the outer side 44B of the handle body 36 for each sensor. The ground layer 37 has holes that allow a portion of the sense activation fields to extend therethrough to the outer side 44B and prevents a portion of the sense activation fields 42A-42E generated by each of the sensors 32A-32E from extending towards the outer side 44B of the door handle 16 while allowing the sense activation fields 42A-42E to extend towards the inner side 44A of the door handle 16 where the first contact surface 30A is located.

In the embodiment shown, the plurality of proximity sensors 32A-32E includes a linear array of five sensors, however, it should be appreciated that one or more proximity sensors may be employed in the array of proximity sensors. Additionally, it should be appreciated that the array of proximity sensors 32A-32E is configured to sense the proximity of objects located at or near the first contact surface 30A on the inner side 44A of the door handle 16 and on the outer side of the door handle 16 at or near the second contact surface 30B, according to one embodiment. However, it should be appreciated that the array of proximity sensors 32A-32E may be provided on a different side of the door handle 16, according to other embodiments. It should further be appreciated that the powered door 12 may be implemented on any side door of the vehicle 10 or another door of the vehicle, such as a vehicle tailgate or an interior door handle according to other embodiments.

The proximity sensors 32A-32E are shown and described herein as capacitive sensors, according to one embodiment. Each capacitive sensor includes at least one capacitive sensor that provides a sense activation field 42A-42E used as a sensing field to sense contact or close proximity (e.g.,

within one millimeter) of an object, such as the hand (e.g., palm and/or fingers) of a user or operator in relation to the one or more proximity sensors 32A-32E. The capacitive sensors may operate as a capacitive switch that may deploy the handle and may unlatch the door latch and may operate as a switch input to control the variable-speed of the door motor for opening the door and closing the door and may be used to detect keypad inputs and may detect gesture inputs. In this embodiment, the sense activation field of each proximity sensor is a capacitive field and the user's hand, including the palm, thumb and other fingers, has electrical conductivity and dielectric properties that cause a change or disturbance in the sense activation field as should be evident to those skilled in the art. However, it should be appreciated by those skilled in the art that additional or alternative types of proximity sensors can be used, such as, but not limited to inductive sensors, optical sensors, temperature sensors, resistive sensors, the like or a combination thereof. Exemplary proximity sensors are described in the Apr. 9, 2009, ATMEL® Touch Sensors Design Guide, 10620 D-AT42-04/09, the entire reference hereby being incorporated herein by reference.

Each of the capacitive sensors may be configured with electrical circuitry that may be printed with conductive ink on a substrate and generally includes a drive electrode and a receive electrode, each having interdigitated fingers for generating a capacitive field, according to one embodiment. It should be appreciated that each of the proximity sensors 32A-32E may otherwise be formed. Each capacitive sensor may have a drive electrode that typically receives a square wave drive pulse applied at a voltage and a receive electrode that has an output for generating an output voltage. It should be appreciated that the electrodes may be arranged in various configurations for generating the capacitive field as the sense activation field.

In one embodiment, the drive electrode of each proximity sensor is applied with a voltage input as square wave pulses having a charge pulse cycle sufficient to charge the receive electrode to a desired voltage. The receive electrode thereby serves as a measurement electrode. When a user or operator, such as a user's hand or thumb or other fingers, enters a sense activation field associated with one of the sensors, the disturbance caused by the hand or fingers to the activation field is detected and a signal is generated. Each of the signals is processed by a controller to determine whether or not a user input is detected and whether to control the door actuator to control the opening speed of the door at a high, medium or low speed, whether to close the door, whether a keypad input to deploy the handle or lock or unlock the door was detected, and whether a swipe gesture command to open or close the door was detected, according to various embodiments. The disturbance of each sense activation field is detected by processing a charge pulse signal associated with the corresponding signal channel. When the user's hand or fingers enter the sense activation fields, the disturbance of each sense activation field is processed via separate signal channels.

The sense activation fields 42A-42E generated by each individual proximity sensor is shown in FIGS. 4A-4C slightly overlapping on the first contact surface 30A on the inner side, however, it should be appreciated that the sense activation fields may be smaller or larger and may overlap more or less depending on the sensitivity of the individual sense activation fields. By employing a plurality of sense activation fields on the interior side of the handle 16 in close proximity to the first contact surface 30A, the size and shape of the hand and the amount of gripping contact with the first

contact surface 30A may be determined based on the sensed signals. The amplitude of each signal may vary based on the size of the hand and the amount of contact on the first contact surface 30A where the sense activation field is located. Additionally, the amount of contact on the first contact surface 30A extending throughout the entire interior surface of the handle 16 may be determined by processing the signals that are generated with all five capacitive sensors. The sum total of two or more of the five signals or an average value of the signals generated by the capacitive sensors may be processed to determine the contact area on the first contact surface 30A and the user input command. Thus, one or all of the proximity sensors 32A-32E may sense the size of the contact area engaged by a user's hand on the first contact surface 30A.

When an initial contact or close contact of a hand is made with the first contact surface 30A on the inner side 44A of the door handle 16, an initial signal level may be established which may be used to unlatch the door 12, particularly when the user is detected in close proximity to the door with a key fob in possession. According to one embodiment, an initial level is established when the user inputs a door unlatch command. However, the initial signal level may be entered at other contact forces. Once unlatched, the door may be controlled to open with the actuator assist based on a user's input applied by the hand contacting the first contact surface 30A of the door handle 16. The actuator may actuate the door opening at a first speed when a greater first size contact area is sensed relative to the initial contact. The actuator may be controlled to actuate the door opening at a greater second speed when a greater second size contact area is sensed relative to the initial contact. The actuator may further be controlled to actuate the door opening at a third speed when a larger third size contact area is sensed relative to the initial contact. Thus, a user may grab the handle 16 and unlatch the door such that the door is free from the body and may open, and then may proceed to apply a desired amount of force onto the first contact surface 30A by gripping the door handle 16 which flattens the hand and increases the contact area applied to the contact surface 30 on the inner side of the handle. The change in the sensed contact area is used to control the speed of the opening of the door with the actuator. By pulling on the door lightly, the first contact area is achieved, whereas by pulling on the door with a greater amount of force resulting in a greater contact with the contact surface 30 of the handle 16, a greater door opening speed may be achieved. By pulling even harder on the door with a greater force in a further enhanced contact surface may be achieved which causes yet a greater door opening speed. Additionally, by pulling on the door handle repeatedly with at least two pulls, a door input command for closing the door may be determined.

The second contact surface 30B on the outer side 44B of the door handle 16 is made up of individual keypad contacts that serve as keypad inputs for enabling a person to enter a sequence of inputs to deploy the handle to the extended position and to lock and unlock the vehicle doors, according to one embodiment. The use of the keypad to deploy the handle and lock and unlock the door(s) works well when the user does not possess the key fob. The user selectable input keypads are shown arranged horizontally on the driver side door, according to one embodiment. The input pads each define a region upon which a user may touch the input pad with a finger or come in close proximity thereto to enter an input selection. The input pads may each include lighted characters that include backlighting and illustrate numerical characters for a corresponding input entry. The characters

may include numerical characters 1 and 2 (1-2) for the first input pad, numerical characters 3 and 4 (3-4) for the second input pad, numerical characters 5 and 6 (5-6) for the third input pad, numerical characters 7 and 8 (7-8) for the fourth input pad and numerical characters 9 and 0 (9-0) for the fifth input pad. It should be appreciated that other characters such as letters or symbols may be employed as input keypad identifiers. Each of the input keypads is aligned with one of the proximity sensors that passes to the second contact surface **30B** on the outer side **44B** of the handle **16** and senses contact or close proximity, e.g., within 1 millimeter of the user's finger with the corresponding keypad and defines a binary switch output (on or off) indicative of a user's selection of that corresponding input keypad.

The light illumination of each of the characters for the corresponding input pads may be achieved by employing a light source **39**, such as one or more LEDs, e.g., RGB LEDs. The light source **39** is in optical communication with a light pipe **40** which extends through openings **38** in the ground layer **37**. As such, light generated by the light source **39** illuminates each of the numerical characters on the outer side of the keypad. The light source may generate colored light including red and green light for use as status indicators.

A user may advantageously input a code as a sequence of inputs into the keypads to deploy the handle and to lock and unlock the vehicle door by entering a programmed sequence of input characters (e.g., numbers) via the keypads labeled with the identifier characters. In the locked state, the door latch assembly **22** is locked such that it will not be able to unlatch and open. When the user interacts with the sense activation field extending within one of the keypads, a signal associated with the corresponding proximity sensor is generated. It should be appreciated that the signal generated by the proximity sensors due to interaction with the sensed activation field on the outer surface **44B** of the door may have a significantly smaller amplitude due to the reduced size and shape of the corresponding activation fields as compared to a signal generated when a user interacts with the first contact surface **30A** on the inner side **44A** of the handle **16** with a similar touch event. Accordingly, the controller may also determine a keypad input based on the lower amplitude and the individual activation of one keypad at a time, as opposed to detecting multiple signals sensing an object on the first contact surface **30A** when a hand interacts with multiple fields at one time.

A user may advantageously input a gesture command, such as a hand or finger swipe movement from left to right or right to left across the linear array of capacitive sensors as a command to open or close the door **12**. The swipe motion may be input when the handle **16** is in either the extended deployed position or the flush stowed position. A swipe motion from left to right may be used as a door open command, whereas a swipe motion from the right to left side may be used as a door close command, according to one embodiment. The swipe motion is detected by detecting a sequential detection of each sensor signal across the linear array within a predetermined time period. The speed of the swipe motion may control the speed of the opening of the door.

Referring to FIG. 5, the controller **80** for determining various user input commands, sensing ice on the handle, and controlling various actuators is illustrated, according to one embodiment. The controller **80** may include a microprocessor **40** and memory **46**. It should be appreciated that the controller **80** may include analog and/or digital circuitry. The controller **80** receives signals from each of the capaci-

5 tive sensors **32A-32E** associated with a door handle. The controller **80** may process the signals to determine a keypad input such as a touch input, a gripping or pulling input, a swipe motion or other gesture input commands, and may further determine an ice accumulation and thickness of ice accumulation on the handle body. The controller **80** also receives inputs from a key fob **82** and may determine the distance between the key fob and each door. A temperature sensor **95** may input a handle temperature or vehicle exterior temperature to the controller **80**. Further, controller **80** may communicate with a Bluetooth enabled device **84**, such as a user's phone and may determine the distance between the Bluetooth enabled device and the doors or the vehicle and the relative position of the Bluetooth enabled device. Further, controller **80** receives an indication of the position of the handle motor and motor current at block **86**, and may also receive ride share information **88** and vehicle speed **90**. The controller **80** processes the input signals pursuant to one or more control routines such as routines **98**, **100**, **150** and **200** which may be executed by the microprocessor **44**. A lookup table **300** stored in memory **96** may store values for controlling the handle motor to break the detected ice based on the ice thickness and temperature, according to one embodiment.

The controller **80** may control various control devices, such as the handle presenter motor **72** to move the handle between the stowed and extended positions, and the handle lighting device **92** to illuminate the handle body and to control the color of the light. Further, the controller **80** may provide control signals to the door actuator **20** to open and close the door and the speed of opening and closing the door. Further, controller **80** may provide control output signals to the door latch assembly **22** and may output Bluetooth enabled and web text outputs **94**.

Referring to FIG. 6, the door handle presenter open routine **100** is illustrated, according to one embodiment. Routine **100** begins at step **102** and proceeds to step **104** to determine if a user input code is entered or typed in on the keypad and a key fob or authorized Bluetooth enabled device such as a phone is within three feet of the door handle and a user's hand is held for three seconds over the keypad or if a key fob is in front of the door handle for more than ten seconds and, if so, proceeds to decision step **106** to determine if a latch override is received and, if not, presents the latch handle to the extended deployed position and flashes the handle light with green light at step **110**. Next, at step **112**, routine **100** opens the door if a swipe open gesture command is detected on the outer side of the presented deployed handle or, if a handle pull is detected on the inner side of the handle. Proceeding to decision step **114**, routine **100** determines if a swipe closed gesture command is detected and, if not, returns to step **118**. If a swipe closed gesture command is detected, routine **100** closes the door at step **116** before returning to step **102**.

If the latch override is received in step **106**, routine **100** proceeds to step **108** to flash the handle light on all handles and to the photograph to obtain images of the inside and outside of the vehicle and transmits the images to a ride share customer who is attempting to enter that latch override that has been executed, and informs a ride sharing service or depot to reschedule the ride and charge the customer who overrode the latch before returning to step **118**.

If in decision step **104**, if neither a code is typed in nor a key fob/phone is within three feet of the door handle while a hand is held for three seconds over the keypad, nor a keypad is in front of the door handle for more than ten seconds, routine **100** proceeds to decision step **120**. At

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decision step **120**, routine **100** determines if the key fob is within three feet of the door handle and a swipe open gesture command is immediately made, or if an autonomous vehicle (AV) trip code has been sent in the last three seconds while the phone was located within five feet of the vehicle, then routine **100** proceeds to decision step **122** to determine if the latch override has been received. If a latch override has been received, routine **122** proceeds to step **108**. If no latch override is received, routine **100** proceeds to step **124** to open the door or, in the case of an autonomous vehicle operation, only present those handles on the doors the customer is to enter through before proceeding to step **114**.

If in decision step **120** neither the key fob is within three feet of the door while a swipe open command motion is immediately detected nor an autonomous vehicle trip code has been sent in the last three seconds while the phone was located within five feet of the vehicle, routine **100** proceeds to decision step **126** to determine if the autonomous vehicle is at a depot and, if so, presents all handles extended to the deployed position when approached by an authorized Bluetooth enabled device so that all handles are in the open position before returning to step **114**.

Referring to FIG. 7, a handle presenter close routine **150** is illustrated, according to one embodiment. Routine **150** begins at step **152** and proceeds to step **154** to determine if a handle is in the deployed position for a time period of more than five seconds; or if a door has been swiped with a close gesture command; or if the vehicle has started to move; or if a key fob/Bluetooth enabled device on a person that typed the code moved more than two feet further away from the vehicle and, if so, closes the handle at step **156** before returning at step **158**. Otherwise, routine **100** returns to step **152**.

The deployable vehicle door handle **16** employs the door actuator in the form of electric motor **72** to deploy and stow the handle body and the door actuator is also used to break ice that forms on the handle body, particularly when the handle body is in the stowed position. Ice formation on the handle body is determined by sensing ice and the thickness of the ice on the handle body with one or more of the capacitive sensors **32A-32E**. An average value of the capacitive sensors **32A-32E** may be employed to sense the presence of ice and the thickness of the ice, according to one embodiment. According to another embodiment, the largest value of the capacitive sensors may be employed to determine ice and ice thickness. Based on known data, the amplitude of the capacitive signal may be compared to a known range of values indicative of ice formed on the handle and the amplitude within that range may indicate the thickness of the ice. In the event that the ice forms an electrical ground path, a grounded ice condition may be detected base on known values.

When ice formation is detected on the handle body, the handle actuator may be activated in such as a manner as to create a hammering action to break the ice from the handle. The hammering action may be achieved by cycling the electric motor **72** in opposite opening and closing directions. The motor current and torque generated with a pulse width modulation signal input the motor **72** can be controlled to create the hammering action. For a handle actuator having a gear such as the worm gear, the cycling of the motor between opening and closing directions may create backlash within the gear arrangement which may further help to break the ice. Given a high torque motor, the motor may be operated at a 100% pulse width modulation for a limited time period, such as five seconds to create the hammering action with forward and reverse motion using the gear lash

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to break the ice. This is in comparison to a motor that may otherwise normally operate at 20% pulse width modulation, according to one example. The handle actuator is controlled to create the hammering action to break the ice based on the thickness of the ice detected. For a greater thickness of ice, the motor torque and hammering action are increased to break the ice, whereas, for a lesser ice thickness, the hammering action and torque may be decreased. Thus, the motor may be controlled to break the ice based on the amount of thickness of the ice detected on the handle.

In addition, the motor may be controlled based on the temperature of the handle or other outside temperature that gives an approximate handle temperature, since the strength of ice may vary based on temperature. The temperature of the handle or outside environment may be measured by a vehicle exterior sensor or a temperature sensor located on or near the handle. Generally, the sheer strength of ice increases with lower temperature. As a result, the motor drive current may be increased at a lower temperature. The amount of motor current or torque needed to generate to break the ice may be stored in a lookup table based on ice thickness and temperature and may be employed to control the motor to break the ice. Alternatively, an algorithm may be employed that computes the motor current or torque for a given temperature and ice thickness.

Referring to FIGS. **8A** and **8B**, the door handle ice handling routine **200** is illustrated, according to one embodiment. Routine **200** begins at step **202** and proceeds to step **204** to acquire one or more of the capacitive sensor signals sensed by the proximity sensors. Next, routine **200** proceeds to decision step **206** to determine if the capacitive sensor signal is outside of a no activity clear range and, if not, returns to step **202**. If the capacitive sensor signal is determined to be outside of the no activity clear range, routine **200** proceeds to decision step **208** to determine if a user touch pattern is detected. If a user touch pattern is detected, routine **200** proceeds to step **210** to process a user touch input before returning to step **202**. If no user touch pattern is detected, routine **200** proceeds to decision step **212** to determine if the signal is stable and, if not, proceeds to step **214** to detect a possible user activity or condensation condition before returning to step **202**. If the signal is stable, routine **200** proceeds to decision step **216** to determine if the signal is detected within an ice range and, if not, returns to step **202**. If the signal is within the ice range, routine **200** proceeds to step **218** to acquire the handle temperature, which may include a temperature of the handle as detected by a temperature sensor on or near the handle indicative of the outside handle temperature. Next, at decision step **220**, routine **200** determines if the temperature is less than 32° F. and, if not, returns to step **202**. If the temperature is determined to be less than 32° F., routine **200** proceeds to step **222** to determine the thickness of the ice accumulated on the handle based on the capacitive sensor signal and a baseline signal. Next, routine **200** calculates a motor pulse width modulation (PWM) from either a lookup table based on the sensed temperature and ice thickness or from an algorithm that computes the ice thickness based on temperature and ice thickness. Next, at decision step **226**, routine **200** determines if the pulse width modulation is greater than a predetermined value such as 100% and, if so, proceeds to step **228** to set the motor burst at about five times the normal maximum torque for a time period of less than five seconds. The increased motor burst creates increased torque in an attempt to break the ice based on the thickness of the ice. If the pulse width modulation is not greater than 100%, routine **200** proceeds to step **230** to activate the motor at a pulse

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width modulation for five seconds, and then rests the motor for five seconds at step 232 before acquiring the capacitive sensor signals seen at step 234. Next, at decision step 236, routine 200 determines if the signal is within the ice range and, if so, determines the ice thickness based on the signal and the baseline, and then returns to step 224. Otherwise, routine 200 returns to step 202.

Referring to FIG. 9, a subroutine 250 for determine the ice thickness on the handle is illustrated, according to one embodiment. Routine 250 begins at step 252 to begin the ice thickness detection subroutine and then proceeds to decision step 254 to determine if the signal is above a sensor clear value. If the signal is above a sensor clear value, routine 250 proceeds to step 256 to use a lookup table or an integral formula to calculate ice thickness based on the signal minus the baseline. If the signal is not above the sensor clear value, routine 250 proceeds to step 258 to use the lookup table or reverse integral to calculate ice thickness based on the baseline minus the signal value. Routine 250 thereafter ends at step 260. It should be appreciated that subroutine 250 continuously determines the ice thickness for use in the routine 200 to control the motor to break the ice on the handle.

Referring to FIG. 10, examples of capacitive sensor signals are illustrated under various conditions. Signal 300 illustrates a capacitive signal during a rain event which causes variations in the signal amplitude due to the movement of the water flowing on or near the handle. Signal 302 illustrates condensation formed on the handle at a relatively high amplitude. Signal 304 illustrates a stable signal generated with a capacitive sensor when ice is formed on the handle and is not grounding the handle. The amplitude of signal 304 may vary within an ice range R_I depending upon the thickness of the ice. The thickness of the ice may be determined with the controller by processing the signal amplitude as described herein. In one embodiment, the thickness of the ice is determined based on the signal amplitude where the signal increases with an increase in ice thickness. The signal 306 indicates a clear handle stable signal when there is no activity on the handle and is shown located within the no activity clear range R_C . Signal 308 illustrates a signal detected when there is ice accumulation on the handle that grounds out the signal. The amplitude of signal 308 may vary within a grounded ice range R_{IG} depending on the thickness of the ice. In this case, the ice creates an electrical ground path that grounds the capacitive signal. Signal 310 illustrates a signal generated when condensation is formed on a handle that is grounded. The controller 80 may advantageously determine the presence of ice and the thickness of the ice on the handle in an ice condition when the signal is within the ice range R_I or grounded ice range R_{IG} , and may further determine ice formed on the handle that is grounded by using a lookup table or an algorithm and may control the handle motor 72 based on the sensed thickness of the ice to break the ice.

The controller 80 may monitor the capacitive sensor signal or signals and determine whether there is a formation of ice on the handle based on the signal amplitude within an ice range, such as signal 304 when the ice does not ground the signal or signal 308 when the ice does ground the signal. Based on the amplitude of signal 304 or signal 308, the thickness of the ice may be determined. When the signal is grounded out, the controller 80 may detect a grounded signal such as signal 308 in which the signal grounding affects the capacitive signal. Accordingly, ice may be detected by monitoring the capacitive signal amplitude and ice thickness

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may be determined when the ice is within an ice range and the ice thickness may be used to control a motor to break the ice.

Accordingly, it should be appreciated that the door handle 16 advantageously employs a deployable handle body with proximity sensors that are used to input gesture commands to control an actuator to deploy the handle. The sensors may be multifunctional and may be used to enter keypad inputs, gesture commands, and door control commands. Additionally, the controller may determine the presence of ice and thickness of ice and may control the actuator to advantageously remove the ice. As a result, the powered door opening assist provides for enhanced door opening functionality.

It is to be understood that variations and modifications can be made on the aforementioned structure without departing from the concepts of the present invention, and further it is to be understood that such concepts are intended to be covered by the following claims unless these claims by their language expressly state otherwise.

What is claimed is:

1. A vehicle door handle comprising:

a handle body;

at least one capacitive sensor for sensing ice on the handle body;

an actuator for actuating the handle body; and

a controller for controlling activation of the actuator to break the ice on the handle body based on the sensed ice, wherein the at least one capacitive sensor senses a thickness of the ice and the controller controls actuation of the actuator based on the sensed thickness.

2. The vehicle door handle of claim 1 further comprising a temperature sensor for sensing temperature proximate the handle body, wherein the controller controls the activation of the actuator further based on the sensed temperature.

3. The vehicle door handle of claim 1, wherein the at least one capacitive sensor comprises a plurality of capacitive sensors.

4. The vehicle door handle of claim 3 further comprising a plurality of keypad contacts, wherein the plurality of capacitive sensors are arranged to sense inputs applied to respective keypad contacts.

5. The vehicle door handle of claim 4, wherein the plurality of capacitive sensors sense a gesture command.

6. The vehicle door handle of claim 1, wherein the handle body is deployable between a stowed position and an extended deployed position.

7. The vehicle door handle of claim 6, wherein the handle body pivots between the stowed and extended deployed positions.

8. A vehicle door handle comprising:

a handle body;

at least one capacitive sensor for sensing ice on the handle body;

an actuator comprising a motor for actuating the handle body; and

a controller for controlling activation of the actuator to break the ice on the handle body based on the sensed ice, wherein the controller activates the motor with increased torque when an increased thickness of ice is sensed.

9. The vehicle door handle of claim 8, wherein the controller controls a pulse width modulation signal of the motor to control the torque.

10. A vehicle door handle comprising:

a handle body located on a door;

a plurality of keypad contacts;

a plurality of capacitive sensors for sensing ice on the handle body;
 an actuator for actuating the handle body to a deployed position; and
 a controller for controlling activation of the actuator to break the ice on the handle body based on the sensed ice, wherein the at least one capacitive sensor senses a thickness of the ice and the controller controls actuation of the actuator based on the sensed thickness.

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11. The vehicle door handle of claim 10 further comprising a temperature sensor for sensing temperature proximate the handle body, wherein the controller activates the actuator further based on the sensed temperature.

12. The vehicle door handle of claim 10, wherein the actuator comprises a motor.

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13. The vehicle door handle of claim 12, wherein the controller activates the motor based on increased torque when an increased thickness of ice is sensed.

14. The vehicle door handle of claim 13, wherein the controller controls a pulse width modulation signal of the motor to control the torque.

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15. The vehicle door handle of claim 10, wherein the plurality of capacitive sensors are arranged to sense inputs applied to respective keypad contacts.

16. The vehicle door handle of claim 15, wherein the plurality of capacitive sensors sense a gesture command.

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17. The vehicle door handle of claim 10, wherein the handle body is deployable between a stowed position and an extended deployed position.

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